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ABSTRACT

Three systems for defining cognitive abilities, proposed by Guilford, Guttman, and the Thurstones, are examined as bases for specifying reference tests for cognitive abilities. The authors propose the cognition of concepts system as a fourth alternative. Tests constructed and/or adapted on the basis of this examination are described. (Author)

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THREE SYSTEMS OF CLASSIFYING COGNITIVE ABILITIES AS BASES FOR REFERENCE TESTS

REPORT FROM THE PROJECT ON A STRUCTURE OF CONCEPT ATTAINMENT ABILITIES

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Theoretical Paper No. 33

THREE SYSTEMS OF CLASSIFYING COGNITIVE ABILITIES AS BASES FOR REFERENCE TESTS

by

Margaret L. Harris and Chester W. Harris

Report from the Project on
A Structure of Concept Attainment Abilities

Robert E. Davidson, Lester S. Golub, Herbert J. Klausmeier,
Thomas A. Romberg, B. Robert Tabachnick, Alan M. Voelker,
Principal Investigators

Mary R. Quilling, Project Manager

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

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Section III materials

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring th at the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Project on the Structure of Concept Attainment Abilities in Program 1. The general objectives of this project are to identify basic concepts in language arts, mathematics, science, and social studies appropriate at a given grade level; to develop tests to measure achievement of these concepts; and to develop and identify reference tests for cognitive abilities. These will be used to study the relationships among learned concepts in various subject matter areas, cognitive abilities, and possibly, certain cognitive styles. The results of these will be a formulation of a model of structure of abilities in concept attainment.

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Abstract

Three systems for defining cognitive abilities, proposed by Guilford, Guttman, and the Thurstones, are examined as bases for specifying reference tests for cognitive abilities. The authors propose the cognition of concepts system as a fourth alternative. Tests constructed and/or adapted on the basis of this examination are described.

I
Introduction

The primary objective of the project entitled "A Structure of Concept Attainment Abilities" (hereafter referred to as the CAA Project) is to formulate one or more models or structures of concept attainment abilities for intermediate level children and to assess their consistency with actual data. The major steps for attaining this primary objective were taken to be:

1. To identify basic concepts in language arts, mathematics, science, and social studies appropriate at the fourth grade level,

2. To develop tests to measure achievement of these concepts,

3. To identify reference tests for cognitive abilities, and

4. To study the relationships among learned concepts in these four subject matter fields and the identified cognitive abilities.

The primary interest, then, of this project is to study the relationships among learned concepts in four subject matter areas (language arts, mathematics, science, and social studies) and cognitive abilities. The factors in such a structure of concept attainment might vary according to semantic content (mathematics, science, etc.), according to type of task involved (definition, classification, etc.), according to the level at which the students operate "a la Piaget" (concrete or abstract operations), and/or according to level of concept mastery (beginning to advanced).

Little is known about the interrelationships of concept attainment within a certain subject and across subject matter areas, or about the basic cognitive abilities that are involved in concept attainment. Do certain abilities contribute to the learning of similar types of concepts across subject matter areas or are there, instead, separate subject matter "abilities"? If concepts tend to group within specific subject matter areas instead of across subject matter, are there certain cognitive abilities which seem to be more important for the learning of concepts in one subject matter than in others? These are the types of questions into which this study proposes to gain some insight. The results of the study should provide a basis for implications for teaching the concepts in these four areas. If there are some broad general groupings of abilities and concepts across subject matter areas, implications for teaching would be of one type, but of another type if the results are highly specific.

Two types of variables will be included in the study of concept attainment abilities. One type will be tests to measure the level of concept attainment in each of four subject matter areas—language arts, mathematics, science, and social studies. The second type will be tests of cognitive abilities; these are often thought of as mental or intellectual abilities or processes.

There are two major phases of Step 3 described in this paper. One is the examination of available systems for defining cognitive abilities followed by the selection and/or construction of tests implied by these systems. The second is the empirical study of the interrelations of these tests in an attempt to validate and/or reconstruct these systems, and will be reported elsewhere.

Although the notion of a single general intellectual ability has been both popular and useful in a number of situations, for the purpose of this project it seems preferable to identify more specific cognitive <u>abilities</u> which may be related to understanding of sub-

ject matter concepts. This paper will discuss the identification of possible cognitive abilities and the nature of tests to measure them.

There are three fairly well-known systems for defining general cognitive abilities. One could, if he wished, accept any one of these systems and use the tests suggested by the developer of the system, or develop tests appropriate for the system adopted, as reference tests for cognitive abilities. Since the three systems are not in complete agreement with each other, and since no one of these systems is widely accepted by experts in the field, it was decided to study the relationships of the three using factor analytic procedures, and, based upon the results of such a study, to determine reference tests for general cognitive abilities to be used in attaining the project's objective stated in Step 4.

The three systems analyzed to determine the nature of possible reference tests for cognitive abilities are the Guilford (1967) analysis of cognition using three contents and six products; the facet design for achievement, consisting of three tasks and three types of content, proposed by Guttman (1970); and the Primary Mental Abilities schema of the Thurstones (1938, 1941). In analyzing these three systems it became apparent that modifications in the schemata of both Guilford and Guttman might be appropriate for content as well as for the operation or task required. This led to a fourth schema for classifying abilities that deal with cognizing concepts.

For factor analysis, it is desirable to have at least two tests to measure each hypothesized ability (each of the identified possible cognitive abilities). Tests were selected, adapted, or constructed as specific measures of the ability implied by a cell of interest in at least one of the schemata, including the newly proposed system of contents and conceptual tasks. Since Guilford's Structure of Intellect is the most specific of the three schemata analyzed, most of the tests were initially chosen from his point of view. Each of the tests can be classified a priori into a relevant cell of each of the schemata.

The systems used to identify possible cognitive abilities and the tests to measure these abilities will be discussed in the following sections.

II
Identification of Possible Cognitive Abilities

A review and integration of early factor analytic studies of aptitude and achievement tests is given by French (1951). Many of the factors obtained by these studies are not cognitive in nature. Those that are cognitive are well represented by the seven clear factors of the Thurstones' (1938, 1941) Primary Mental Abilities. Since 1951 Guilford (1967) has developed the Structure of Intellect consisting of 120 possibly distinct abilities and Guttman (1970) has proposed a facet design consisting of nine different abilities. The work of both Guilford and Guttman depends at least in part on the work of the Thurstones. Guilford (1972) has recently commented on this dependency. Guttman arrived at his facet design following reanalyses of the Thurstones' data (Guttman, 1965a).

Guilford's Structure of Intellect

Guilford's (1967) Structure of Intellect schema consists of 120 possibly distinct abilities which can be represented by a cube. The three facets, or parameters as Guilford calls them, are named operations, contents, and products. The Structure of Intellect model is illustrated in Figure 1.

The operation facet, i.e., classifying abilities according to the kind of operation involved, consists of five operations named cognition, memory, divergent production, convergent production, and evaluation. Guilford defines cognition as knowing or understanding. "Cognitive abilities" is a term that as used by many may include all intellectual abilities. Guilford prefers to use the term "intellect" to mean the entire range of all abilities, i.e., the Structure of Intellect, and to use the term "cognition" in a more limited sense. Memory refers to the several abilities to remember, and evaluation to the abilities to compare a product of information with known information according to logical criteria. Guilford thought that reasoning could not be uniquely defined and thus would prove to be a poor categorical label. Instead, he developed two categories which he called divergent production and convergent production. Divergent production involves fluency, flexibility, and elaboration abilities; these are often called creative thinking abilities. Convergent production involves converging upon the one right answer according to the information given.

The content facet consists of four contents: semantic, symbolic, figural, and behavioral. Guilford uses the term semantic to mean what has been traditionally thought of as "verbal." However, in the tests he has constructed and adapted, semantic content includes both words and pictures. Figural content is what is traditionally thought of as figural, i.e., designs. These two categories reflect the traditional verbal versus nonverbal distinctions. A third content parallels these two—symbolic content, typically represented in tests by numbers or letters. In these tests, Guilford uses numbers, single letters, groups of letters making nonsense syllables, and groups of letters making up real English words. He uses numbers in each of two ways, purely as symbols without any cardinal implications, and as cardinal numbers. The fourth category, behavioral, was added purely on logical grounds but since that time Guilford reports isolating behavioral abilities in his studies.

The product parameter consists of six products: units, classes, relations, systems, transformations, and implications. These describe the form in which information occurs. Guilford perceives units as things or segregated wholes; classes as sets of objects with one or more common properties (these are called concepts by many persons); relations as some kind of connection between two things; systems as complexes, patterns, or organizations of

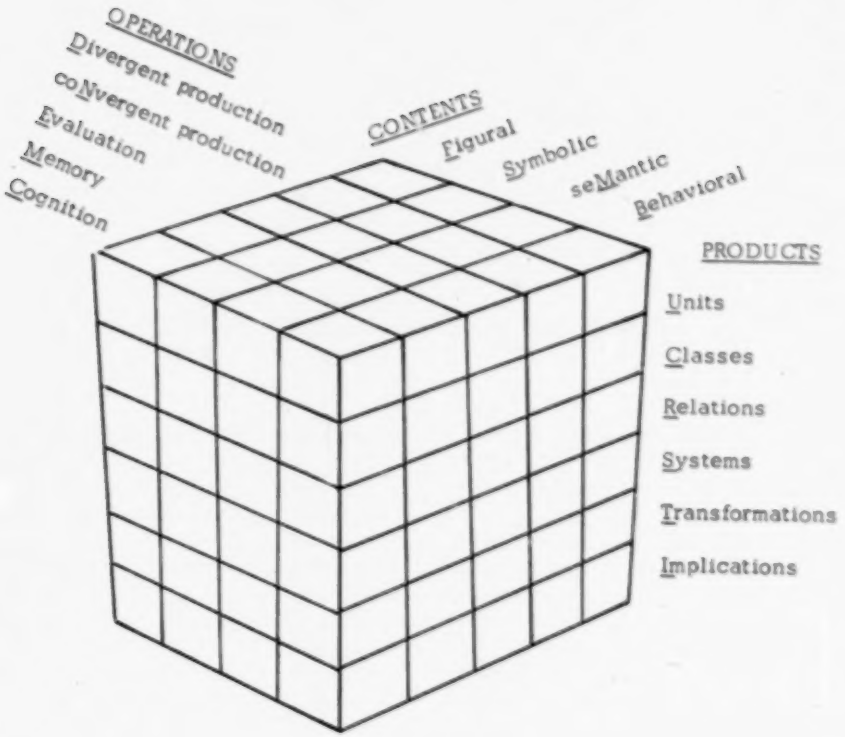


Fig. 1. Guilford's Structure of Intellect Model

interdependent or interacting parts; transformations as changes, revisions, redefinitions, or modifications by which any product of information in one state goes into another state; and implications as something expected, anticipated, or predicted from given information. A helpful illustration of these six kinds of products, using visual-figural content for the examples, can be found on page 64 in Guilford (1967).

The aspects of Guilford's Structure of Intellect that are of major interest for this project are cognition as an operation, semantic content, and classes as products. In making use of the Guilford analysis of cognition, four products—units, classes, relations, and systems—appeared to be most relevant and most easily defined in an unambiguous fashion. For these, the three contents of primary interest are semantic, symbolic, and figural. Thus, tests were included as measures of cognition of semantic, symbolic, and figural units, classes, relations, and systems as defined by Guilford. (Cognition of figural systems was not included, however.) Since semantic content and classes as products are of major interest, tests designed as measures of memory, convergent production, and evaluation of semantic classes were also included. It was decided that no attempt would be made to include divergent production abilities. One other Guilford Structure of Intellect cell was of major interest, evaluation of semantic relations. Jones (1968) found that tests of this ability were related to concept learning.

A battery of 56 tests was compiled to study the relationships of the Guilford, Guttman, and Thurstone schemata. The nature of the tests and the a priori categorization of each of the 56 tests in the Structure of Intellect cells of interest are discussed in Section III.

Guttman's Facet Design

Guttman's (1970) design for constructing

tests of intellect is a two-facet design. The language of communication facet has three elements or types of content: verbal, numerical, and pictorial (geometric). The pictorial content was earlier called "figural" (Schlesinger & Guttman, 1969) and before that "geometrical" with an explanation that pictures, whether objective or non-objective, gave a third type of content or language of communication (Guttman, 1965b). Thus, it is possible that Guttman would regard pictures of real things and geometrical representations or figures that have no obvious, real referent as members of the same content category. Alternatively, one could classify pictures of real things as semantic content.

The second facet is the type of task imposed on the subject and has three elements: rule-inferring, rule-applying, and school achievement (rule-applying when the rule is taught formally in the school system). Rule-inferring and rule-applying were earlier called analytical ability and achievement, respectively (Guttman, 1965b; Schlesinger & Guttman, 1969). The addition of the third element, school achievement, was first suggested in the 1969 publication.

In developing his two-facet design, Guttman obtained results of this type when analyzing (by Smallest Space Analysis) the data from the Primary Mental Abilities of the Thurstones (Guttman, 1965a) and some of Guilford's original data (Guttman, 1965b).

Guttman's two-facet design, consisting of three tasks and three types of content, generates nine different abilities. Of primary importance for the portion of the total CAA Project having to do with the identification of reference tests for cognitive abilities are the two tasks of rule-inferring and rule-applying for the three contents. It was felt that in the study of the relationships among learned subject-matter concepts and general cognitive abilities (Step 4 of the objectives), the school achievement task of Guttman's facet design would be well represented by the concept attainment tests for the four subject matter fields being studied. There are, however, some tests in the experimental battery of 56 tests that might be classified under the achievement task; the majority of these are verbal in content. This will be discussed in Section III along with the a priori categorization of each of the 56 tests within Guttman's nine-factor or ability schema.

Thurstone Primary Mental Abilities

In several studies the Thurstones isolated seven clear factors which have become well known as the Primary Mental Abilities. In the first study, 60 tests were administered to 218 college students, the factor results of which yielded clear factors which were called S, P, N, V, M, W, and I—spatial, perceptual, numerical, verbal relations, memory, word fluency, and inductive (Thurstone, 1938). Two other factors which were not so clear were tentatively named R (restrictive task ability or a form of reasoning) and D, deductive. In a later study, 60 tests, some of which were the same type as used in the earlier study, were administered to 710 eighth grade children (Thurstone & Thurstone, 1941). Once again the same seven clear factors resulted—S, P, N, V, M, W, and I. The V factor was renamed verbal comprehension instead of verbal relations. Two tests were also included to measure the D factor but neither an R nor a D factor was found. The a priori categorization of each of the 56 tests in the battery within this schema of eight abilities is discussed in Section III.

The Three Schemata as a Guide to Test Development

Test development included the construction of tests, the adaptation of existing tests, and the selection of appropriate published tests. A brief description of the 56 tests developed, with a sample item for each, appears beginning on page 17. In developing these tests an attempt was made to provide two or more tests for each of the Guilford Structure of Intellect cells, for each of six cells of the Guttman design, and for each of the seven Thurstone Primary Mental Abilities. Because the three systems are alternative analyses of the same domain, a test selected in terms of one of the schemata usually can be readily classified in each of the other two schemata. In fact, our hope was to be able to classify every test according to Guilford, to Guttman, and to Thurstone. A table listing the 56 tests and giving their classifications begins on page 10. The Guilford Laboratory Reports and his 1967 volume were a major resource. It was not possible, however, simply to use tests Guilford had employed since many of these tests were first developed for use with persons older than the fifth grade students we intended to use as subjects.

A Fourth Schema

In working with these three schemata it

became apparent that a fourth schema might be appropriate for the purpose of defining abilities to cognize concepts. This one is restricted in scope. It reanalyzes the notion of content for such abilities and distinguishes two types of exemplars independent of the "content" in which they are presented. Further, it identifies three different tasks, each of which appears to be a type of cognizing. Thus this fourth schema postulates abilities to cognize concepts in a structure or type of content, type of exemplar, and type of task.

Content

There appear to be seven distinguishable kinds of content for tests of cognition rather than the three suggested by Guilford (excluding the behavioral) and the three suggested by Guttman. These seven kinds of content are: verbal-semantic (one may get meaning from words or groups of words), pictorial-semantic (one may get meaning from pictures), number-semantic (one may get meaning from numbers as cardinal numbers), figural (using shapes that have no inherent meaning), number-symbolic (using numbers as symbols), letter-symbolic (using letters as symbols), and word-form (using words as forms where the configuration of the letters is the important aspect and not the meaning of the word). The Guilford schema seems to combine the first three of these into one (semantic), to include figural, and to combine the last three into one (symbolic). The first two of these seem to be two of the contents of the Guttman schema (verbal and numerical), but the third Guttman content is unclear; it may be figural. The Primary Mental Abilities are not organized independently according to contents as are the Guilford and Guttman schemata. However, three of the primary mental abilities are essentially the same as three of our contents: verbal-semantic, number-semantic, and figural (but in a very special sense—that of perceiving spatial relationships). Word fluency uses verbal-semantic content, perceptual speed uses figural content, the Primary Mental Abilities inductive includes figural and several kinds of symbolic contents, deductive uses all kinds of semantic contents, and memory may use any of the seven kinds of contents.

Nature of Exemplars

There appear to be two forms in which exemplars can be presented when one wants to measure abilities to cognize classes. One of these uses exemplars that represent things (units in Guilford's terms), and the other uses exemplars that represent relations (relations and series types of systems in Guilford's terms). In other words, one may cognize concepts that are exemplified by things or concepts that are exemplified by relations. Examples of multiple-choice items of these two types using verbal-semantic content are:

Example 1 (Things)

Which word on the right belongs to the group on the left?

1. steak	A. egg
milk	B. knife
orange	C. dish
onion	

Example 2 (Relations)

Which word on the right goes with the third one the same way the second one goes with the first one?

2. HAND is to MAN as PAW is to

A. boy
B. dog
C. bird
D. foot

In Example 1 a class of things is presented, i.e., foods; in Example 2 a relation or class of relations is presented, i.e., a man's hand is like a dog's paw. Note that for cognizing a class of things it is necessary to have more than one exemplar so that the class can be deduced, but for cognizing relations only one exemplar may be necessary. If the relation is a series, more than one exemplar is necessary. An illustration of this is:

Example 3 (Series Type of Relations)

In which blank does the word on the right belong?

3. _____Monday_____Wednesday_____
A B C
Thursday_____Friday_____ (Tuesday)
D E

Tasks

There appear to be three different tasks

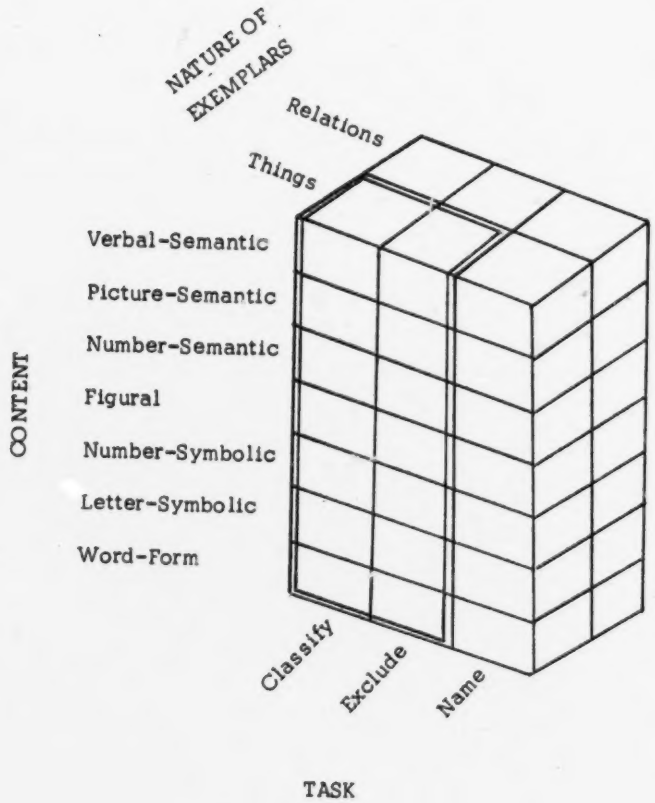


Fig. 2. Design for the Cognition of Concepts

which can indicate cognizing a class or a concept represented by exemplars. Two of these are especially interesting. One uses the ability to select another exemplar to go with a given set of exemplars of a class. The other uses the ability to exclude a nonexemplar from a set of exemplars of a class. Examples of multiple-choice items of these two types using word-form content are:

Example 4 (Classification)

Which word on the right belongs with the group of words on the left?

4.	mist	A. mask
	mast	B. moss
	most	C. must
		D. mint

Example 5 (Exclusion)

Which word does not belong?

5. A. mist B. mast C. moss D. most

Note that the three items given earlier as illustrations of exemplars being things or relations each use the classification type of task, and that these two examples given as illustrations of tasks each use things as exemplars.

The other task is a naming task, that of selecting an appropriate class name given a set of exemplars.

A representation of this analysis of abilities to cognize concepts represented by exemplars is given in Figure 2.

It was decided to study only a piece of this design in detail. The portion of the total

design selected for detailed study consists of the seven contents, the two tasks of classification and exclusion, and things as exemplars; it is one third of the total design and is set off by double lines in Figure 2. Tests which are classified as measures of some of the other cells in the design are also included, but no attempt was made to rigorously study the entire design. It also should be pointed out here that this design for cognizing concepts is closely related to the schema being used in the CAA Project for measuring attainment of subject matter concepts (Frayer, Fredrick, & Klausmeier, 1969). Studying a portion of this design may provide evidence on the level of specificity of cognitive abilities. For example, factors ranging in generality from a single general factor to doublets or triplets representing cells of Figure 2 may be found.

The a priori categorization of each of the 56 tests being studied to identify cognitive abilities for the CAA Project will be discussed in the following section. With respect to the fourth schema, each of the tests is categorized in the content dimension; only those tests which deal with cognition of concepts are categorized in the task and nature of exemplars dimensions.

III
Tests to Measure the Possible Cognitive Abilities

A battery of 56 tests was developed to study the relationships among the Guilford, Guttman, and Thurstone schemata. For factor analysis, it is desirable to have at least two (and preferably three) tests to measure each hypothesized ability (each of the identified possible cognitive abilities). Tests were selected, adapted, or constructed as specific measures of the ability implied by a cell of interest in at least one of the schemata, including the newly proposed system for the cognition of concepts. Since Guilford's Structure of Intellect model is the most specific of the three schemata analyzed, most of the tests were initially chosen from his point of view. It should be pointed out here, however, that many of these tests are of the same type as those initially studied by the Thurstones. Each of the tests can be classified, a priori, into a relevant cell of each of the schemata.

The nature of the 56 tests and their classification in each of the schemata will be discussed in this section.

Classification of the Tests in Each of the Schemata

The a priori classification of each of the 56 tests in each of the schemata is given in Table 1. The tests are listed in the order of administration. An alphabetical listing of the tests with numbers corresponding to this table is given in Appendix A for ease in locating any particular test of interest. Note that five Guilford cells not discussed as cells of major interest are included in Table 1. They are cognition of figural transformations (CFT), memory of symbolic implications (MSI), convergent production of semantic systems (NMS), evaluation of semantic implications (EMI), and evaluation of figural units (EFU). Tests which Guilford says are measures of the abilities implied by these cells were selected for inclusion primarily to measure an ability in another one of the schemata.

For each of the tests, there is either an asterisk, a y, or an x in one of the columns for each of the schemata. (Note that for Cognition of Concepts each test has an x in the content dimension, but only those tests that deal with cognizing concepts are classified with respect to the nature of exemplars and task dimensions.) An asterisk means that the developer of the schema says the test measures the ability implied by that column in the schema; it is the primary classification and/or source of the test. A y means that the test was selected by us primarily to measure the ability implied by that column in that schema. An x stands for our a priori, secondary classification of the test in each of the remaining schemata. It should be pointed out here that the basis for the secondary classification for most of the tests was obtained from the literature. Thirteen of the tests—Numbers 11, 14, 18, 19, 20, 22, 25, 29, 30, 40, 45, 46, and 54—have primary classification status in both the Guilford and the Thurstone schemata. (Verbal Exclusion is our name for Guilford's Word Classification, and Necessary Arithmetic Operations is often called Arithmetic Reasoning.) Six of the tests do not have an asterisk or a y (primary classifications) in any of the columns. Four of these—5, Number Class Extension; 27, Letter Classification; 38, Number Exclusion; and 49, Word Exclusion—were constructed to complete the portion of the proposed Cognition of Concepts system that was selected for rigorous study—the classification and exclusion of things for all seven of the kinds of content. The other two—7, Remembering Classes: Members II; and 56, Remembering Classes: Members III—are the same test as 4, Remembering Classes: Members; in other words, the same test was administered three different

Table 1. Classification of Each of the 56 Tests in Each of the Schemata

	Guilford									
Test	CMU	CMC	CMR	CMS	CSU	CSC	CSR	CSS	CFU	CFC
1 Picture Meaning	x									
2 Verbal Classification		*								
3 Number Series								*		
4 Remembering Classes: Members										
5 Number Class Extension						x				
6 Word Groups						*				
7 Remembering Classes: Members II										
8 Disemvowelled Words					*					
9 Letter Grouping						*				
10 Circle Reasoning								*		
11 Figure Exclusion										*
12 Seeing Trends							*			
13 Picture Classification		y								
14 Paragraph Comprehension	*									
15 Remembering Classes: Names										
16 Word Group Naming										
17 Gestalt Completion									*	
18 Card Rotations										
19 Spatial Relations										
20 Verbal Exclusion		*								
21 Best Word Class										
22 Omelet					*					
23 Picture Group Naming										
24 Concealed Words									*	
25 Perceptual Speed										
26 Letter Triangle								*		
27 Letter Classification						x				
28 Picture Class Memory										
29 Puzzles										
30 Spelling					*					
31 Picture Exclusion		y								
32 Sensitivity to Order			*							
33 Figure Analogies										
34 Scrambled Sentences	*									
35 Same-Opposite	x									
36 Figure Matrix										
37 Remote Class Completion										
38 Number Exclusion						x				
39 Sentence Order										
40 Vocabulary	x									
41 Word Relations							*			
42 Verbal Analogies			*							
43 Best Trend Name										
44 Picture Arrangement										
45 Arithmetic Problems										
46 Identical Pictures										
47 Picture Group Name Selection										
48 Number Classification						*				
49 Word Exclusion						x				
50 Number Relations						*				
51 Word Linkage			*							
52 Figure Classification										*
53 Class Name Selection										
54 Necessary Arithmetic Operations				*						
55 Verbal Analogies III										
56 Remembering Classes: Members III										

Table 1. Classification of Each of the 56 Tests in Each of the Schemata (continued)

Test	Guilford									
	CFR	CFT	MMC	MSI	NMC	NMS	EMC	EMR	EMI	EFU
1 Picture Meaning										
2 Verbal Classification										
3 Number Series										
4 Remembering Classes: Members			y							
5 Number Class Extension										
6 Word Groups										
7 Remembering Classes: Members II			x							
8 Disemvowelled Words										
9 Letter Grouping										
10 Circle Reasoning										
11 Figure Exclusion										
12 Seeing Trends										
13 Picture Classification										
14 Paragraph Comprehension										
15 Remembering Classes: Names			*							
16 Word Group Naming					y					
17 Gestalt Completion										
18 Card Rotations		*								
19 Spatial Relations		*								
20 Verbal Exclusion										
21 Best Word Class							*			
22 Omelet										
23 Picture Group Naming					y					
24 Concealed Words										*
25 Perceptual Speed										
26 Letter Triangle										
27 Letter Classification										
28 Picture Class Memory			*							
29 Puzzles									*	
30 Spelling										
31 Picture Exclusion										
32 Sensitivity to Order										
33 Figure Analogies	*									
34 Scrambled Sentences										
35 Same-Opposite										
36 Figure Matrix	*									
37 Remote Class Completion					y					
38 Number Exclusion										
39 Sentence Order						*				
40 Vocabulary										
41 Word Relations										
42 Verbal Analogies										
43 Best Trend Name								*		
44 Picture Arrangement						*				
45 Arithmetic Problems				*						
46 Identical Pictures										*
47 Picture Group Name Selection							y			
48 Number Classification										
49 Word Exclusion										
50 Number Relations										
51 Word Linkage										
52 Figure Classification										
53 Class Name Selection							*			
54 Necessary Arithmetic Operations										
55 Verbal Analogies III								*		
56 Remembering Classes: Members III			x							

Table 1. Classification of Each of the 56 Tests in Each of the Schemata (continued)

Test	Guttman RI: V	RI: N	RI: P	RA: V	RA: N	RA: P	A: V	A: N	A: P
1 Picture Meaning									x
2 Verbal Classification	x								
3 Number Series		x							
4 Remembering Classes: Members				x					
5 Number Class Extension		x							
6 Word Groups	(RI: no content for)								
7 Remembering Classes: Members II				x					
8 Disemvowelled Words							x		
9 Letter Grouping	(RI: no content for)								
10 Circle Reasoning			x						
11 Figure Exclusion			x						
12 Seeing Trends	(RI: no content for)								
13 Picture Classification			x						
14 Paragraph Comprehension							x		
15 Remembering Classes: Names				x					
16 Word Group Naming	x								
17 Gestalt Completion						x			
18 Card Rotations						x			
19 Spatial Relations						x			
20 Verbal Exclusion	x								
21 Best Word Class	x								
22 Omelet							x		
23 Picture Group Naming			x						
24 Concealed Words						x			
25 Perceptual Speed						x			
26 Letter Triangle	(RI: no content for)								
27 Letter Classification	(RI: no content for)								
28 Picture Class Memory						x			
29 Puzzles							x		
30 Spelling							x		
31 Picture Exclusion			x						
32 Sensitivity to Order	x								
33 Figure Analogies			x						
34 Scrambled Sentences							y		
35 Same-Opposite				y					
36 Figure Matrix			x						
37 Remote Class Completion	x								
38 Number Exclusion		x							
39 Sentence Order				y					
40 Vocabulary							x		
41 Word Relations	(RI: no content for)								
42 Verbal Analogies	x								
43 Best Trend Name	x								
44 Picture Arrangement						y			
45 Arithmetic Problems								x	
46 Identical Pictures						x			
47 Picture Group Name Selection			x						
48 Number Classification		x							
49 Word Exclusion	(RI: no content for)								
50 Number Relations		x							
51 Word Linkage							x		
52 Figure Classification			x						
53 Class Name Selection	x								
54 Necessary Arithmetic Operations					x				
55 Verbal Analogies III	x								
56 Remembering Classes: Members III				x					

Table 1. Classification of Each of the 56 Tests in Each of the Schemata (continued)

				Thurstone					
Test	S	P	N	V	W	M	I	D	C_1
1 Picture Meaning				*					
2 Verbal Classification							x		
3 Number Series							x		
4 Remembering Classes: Members						x			
5 Number Class Extension							x		
6 Word Groups							x		
7 Remembering Classes: Members II						x			
8 Disemvowelled Words					x				
9 Letter Grouping							x		
10 Circle Reasoning							x		
11 Figure Exclusion							*		
12 Seeing Trends							x		
13 Picture Classification							x		
14 Paragraph Comprehension				*					
15 Remembering Classes: Names						x			
16 Word Group Naming							x		
17 Gestalt Completion									x
18 Card Rotations	*								
19 Spatial Relations	*								
20 Verbal Exclusion							*		
21 Best Word Class							x		
22 Omelet					*				
23 Picture Group Naming							x		
24 Concealed Words									x
25 Perceptual Speed		*							
26 Letter Triangle							x		
27 Letter Classification							x		
28 Picture Class Memory						x			
29 Puzzles								*	
30 Spelling					*				
31 Picture Exclusion							x		
32 Sensitivity to Order							x		
33 Figure Analogies							x		
34 Scrambled Sentences				x					
35 Same-Opposite				x					
36 Figure Matrix							x		
37 Remote Class Completion							x		
38 Number Exclusion							x		
39 Sentence Order				x					
40 Vocabulary				*					
41 Word Relations							x		
42 Verbal Analogies				x					
43 Best Trend Name							x		
44 Picture Arrangement				x					
45 Arithmetic Problems			*						
46 Identical Pictures		*							
47 Picture Group Name Selection							x		
48 Number Classification							x		
49 Word Exclusion							x		
50 Number Relations							x		
51 Word Linkage				x					
52 Figure Classification							x		
53 Class Name Selection							x		
54 Necessary Arithmetic Operations								*	
55 Verbal Analogies III				x					
56 Remembering Classes: Members III						x			

Table 1. Classification of Each of the 56 Tests in Each of the Schemata (continued)

Test	Nature of Exemplars		Cognition of Concepts: Content							Task		
	T	R	V-M	P-M	N-M	F	N-S	L-S	W-F	C	E	N
1 Picture Meaning				x								
2 Verbal Classification	x		x							x		
3 Number Series		x			x					x		
4 Remembering Classes: Members			x									
5 Number Class Extension	x				x					x		
6 Word Groups	x								x	x		
7 Remembering Classes: Members II			x									
8 Disemvowelled Words			x									
9 Letter Grouping	x							x			x	
10 Circle Reasoning		x				x				x		
11 Figure Exclusion	x					x					x	
12 Seeing Trends		x							x	x		
13 Picture Classification	x			x						x		
14 Paragraph Comprehension			x									
15 Remembering Classes: Names			x									
16 Word Group Naming	x		x									x
17 Gestalt Completion				x								
18 Card Rotations						x						
19 Spatial Relations						x						
20 Verbal Exclusion	x		x								x	
21 Best Word Class	x		x									x
22 Omelet			x									
23 Picture Group Naming	x			x								x
24 Concealed Words			x									
25 Perceptual Speed						x						
26 Letter Triangle		x						x		x		
27 Letter Classification	x							x		x		
28 Picture Class Memory				x								
29 Puzzles			x									
30 Spelling			x									
31 Picture Exclusion	x			x							x	
32 Sensitivity to Order		x	x							x		
33 Figure Analogies		x				x				x		
34 Scrambled Sentences			x									
35 Same-Opposite			x									
36 Figure Matrix		x				x				x		
37 Remote Class Completion	x		x							x		
38 Number Exclusion	x						x				x	
39 Sentence Order			x									
40 Vocabulary			x									
41 Word Relations		x							x	x		
42 Verbal Analogies		x	x							x		
43 Best Trend Name		x	x									x
44 Picture Arrangement				x								
45 Arithmetic Problems					x							
46 Identical Pictures						x						
47 Picture Group Name Selection	x			x								x
48 Number Classification	x						x			x		
49 Word Exclusion	x								x		x	
50 Number Relations		x			x						x	
51 Word Linkage			x									
52 Figure Classification	x					x				x		
53 Class Name Selection	x		x									x
54 Necessary Arithmetic Operations			x		x							
55 Verbal Analogies III		x	x							x		
56 Remembering Classes: Members III			x									

Table 1. Classification of Each of the 56 Tests in Each of the Schemata (continued)

Key: * Developer's identification and/or source
y Test was selected to measure this ability
x Secondary classification in alternative schema

Key to Schema Classifications:

Guilford

Operations: (letter 1)
- C Cognition
- M Memory
- D Divergent-Production
- N Convergent-Production
- E Evaluation

Contents: (letter 2)
- M Semantic
- S Symbolic
- F Figural

Products: (letter 3)
- U Units
- C Classes
- R Relations
- S Systems
- T Transformations
- I Implications

Guttman
- RI Rule-Inferring
- RA Rule-Applying
- A Achievement or rule-applying when the rule used is formally taught in school
- V Verbal
- N Numerical
- P Pictorial

Thurstone
- S Spatial
- P Perceptual Speed
- N Numerical
- V Verbal
- W Word Fluency
- M Memory
- I Induction
- D Deduction
- C_1 Closure One

Cognition of Concepts

Nature of Exemplars:
- T Things
- R Relations

Content:
- V-M Verbal-Semantic
- P-M Picture-Semantic
- N-M Number-Semantic
- F Figural
- N-S Number-Symbolic
- L-S Letter-Symbolic
- W-F Word-Form

Task:
- C Classify
- E Exclude
- N Name

times. This was done to study possible differences in memory as a function of time intervening between study and recall of the material studied. Test 4 (Remembering Classes: Members) was given immediately following study of the material. Remembering Classes: Members II is this same test given at the end of the same testing session with two other tests intervening but without restudy of the material. Remembering Classes: Members III was given on the last day of testing with seven days intervening for girls and three days for boys, again without restudy of the material.

As can be seen from Table 1, the newly proposed system for the cognition of concepts is the most specific. As was discussed in the previous section, it really forms a seven by four by two matrix. Of the three published schemata analyzed, Guilford's Structure of Intellect is the most specific. There are many interesting relationships, according to the hypothesized classifications, which can be seen by studying Table 1. Just a few of them will be pointed out.

Each column in the table is different with one exception; there is no ability that is the same in any two of the schemata being studied except for Guilford's CSU and Thurstone's W. Note that in classifying the Perceptual Speed ability of the Thurstones' Primary Mental Abilities in each of the other schemata, the speeded aspect of this ability had to be ignored. Guilford (1972) says speed is not an important feature. Seven tests which would be Rule-inferring in the Guttman system were not classified according to content because it was felt there was no content which was really appropriate. Instead of classifying them as either Verbal or Pictorial, we preferred to leave them unclassified along the content dimension or facet.

An interesting relationship exists among the tests classified under Thurstone's Induction and Guttman's Rule-inferring, and having a three-way classification under Cognition of Concepts. All 31 tests that involve the cognition of concepts (have a three-way classification in this system) are classified as Induction in the Thurstone Primary Mental Abilities and Rule-inferring in Guttman's facet design, except for 42, Verbal Analogies, and 55, Verbal Analogies III, which are classified as Thurstone's V. The most general classification is Induction, containing all but two of these tests; Guttman calls this general ability Rule-inferring and says it is specific to three kinds of content thus classifying these tests under three different abilities; while the system for cognizing concepts becomes very specific with the addition of four more contents, four types of tasks (only two are complete), and two different natures of exemplars for what is being cognized (only one is complete). There is no clear organization for these 31 tests in the Guilford system. Many of them are classified as cognition of classes for the three different contents, but other classifications include cognition of relations and systems, and convergent production and evaluation of classes. Note that tests having relations as exemplars in the Cognition of Concepts schema are either called relations or systems as a product in the Guilford schema with the exception of one test, Number Relations (50). We call the exemplars given for this test relations, but Guilford calls the product classes (things in our schema).

Nature of the Tests

The nature and source of each of the tests will be discussed here.

For the 56 tests in the battery, the subjects responded on a separate machine-scorable answer sheet for 45 of the tests and wrote their answers directly in the test booklet for the remaining 11 tests. These 11 tests were hand-coded onto machine-scorable answer sheets; this will be noted in the description of these tests. When no mention is made of mode of response for a test, the response was made on a separate answer sheet which was machine scored. An example item will be included for each of the tests. These are not items which were a part of the test; most of them were used as examples in the test directions.

The tests are discussed in the order in which they were administered. The number in parentheses gives this order. An alphabetical listing of the tests with their administration order number can be found in Appendix A for ease in locating any particular test of interest.

The 35 tests which were constructed for this project are described in "Newly Constructed Reference Tests for Cognitive Abilities" (Harris & Harris, in press).

PICTURE MEANING (1)

This is a picture vocabulary test. The subject is given pictures of four things, e.g., a chair, a dog, a boat, and a bird, and is told to "find the dog." It is used in the Primary Mental Abilities (PMA) Thurstone, 4-6 test battery (1962) as a test to measure verbal meaning. Permission was received from the publisher, Science Research Associates, Inc., to reproduce this test for our research purposes.

Example:

VERBAL CLASSIFICATION (2)

This test is our adaptation of Guilford's Verbal Classification test (which was adapted from Thurstone). We simplified the format for use with fifth graders and made it machine scorable. The subject is given four exemplars which belong to the same class. He is to infer the class and then choose, from three choices, another exemplar of that class.

Example:	steak	A. egg
	milk	B. knife
	orange	C. dish
	onion	

NUMBER SERIES (3)

This is a typical number series test in which exemplars forming a series are given and the subject must infer a quantitative rule and choose the number which would come next in the series from five choices which are given. The rule is based on addition, subtraction, multiplication, division, powers, roots, etc. It may be noted here that we experimented with the type where any one number in the series may be incorrect and the task is to find this one incorrect number. It was found that this type of number series item was too difficult for fifth graders.

Example: 7 8 9 10 ___

A. 7
B. 8
C. 10
D. 11
E. 12

REMEMBERING CLASSES: MEMBERS (4)

This test was suggested by Guilford's Remembering Classes test. His test calls for inferring and remembering class names. (Our test of this type is called Remembering Classes: Names.) For this test the subject studies 10 sets of three words. Immediately following the study period, he is asked to respond whether or not each of 20 sets of two words belongs to a class that was studied. Each set of two words contains one word from a studied set of three words. This was an attempt to make the task more a memory for classes than a memory for specific things studied. It was felt that this type of test may be a "remembering classes" test more than one which calls for inferring and then remembering a class name; the latter type may be more dependent on being able to name the class.

Example: chair
desk
bed

A. chair
sofa

B. chair
door

NUMBER CLASS EXTENSION (5)

This test was constructed to fill the "classification of things using number-semantic content" cell of the Cognition of Concepts schema. The test calls for inferring a class from four given numbers and selecting another exemplar of that class from three given choices.

Example: 3
9
12
21

A. 2
B. 6
C. 13

WORD GROUPS (6)

This test is our adaptation of Guilford's Word Groups. We changed the format to make it machine scorable. The subject is given four words, using words as collections of letters or forms, and is asked to add an exemplar to that class from three given choices.

Example: ran
man
can
tan

A. fat
B. fan
C. cat

REMEMBERING CLASSES: MEMBERS II (7)

This test is identical to Test 4, Remembering Classes: Members. It was administered at the end of the testing session which included Tests 4 through 7 without any further study of the material given. Thus, it is a second administration of Test 4 with two tests intervening.

DISEMVOWELLED WORDS (8)

This test is our adaptation of Guilford's Disemvoweled Words test. Words with blanks where vowels normally appear in the spelling of the word are given. The subject is asked to give the vowel which belongs in the blank.

Example: Y__S T__R D__Y
1 2 3

LETTER GROUPING (9)

This test is our adaptation of Guilford's Letter Grouping test. The test was originated by L. L. Thurstone. The subject is given four groups of three or four letters each. He is to infer a class and then choose the group which is different (does not belong to the class). This is an exclusion technique, selecting the nonexemplar, as opposed to a classification one of adding another exemplar.

Example: 1. AAA 2. BBB 3. CCC 4. ABC

CIRCLE REASONING (10)

This test is our adaptation of Guilford's Circle Reasoning test to make it appropriate for fifth graders. The subject is to infer a position rule for a darkened circle from four exemplars (rows of dashes and circles with one darkened circle) and to add another exemplar (darken the correct circle in a fifth row according to the rule). Guilford used 15 circles and dashes in each row of his test; we used seven.

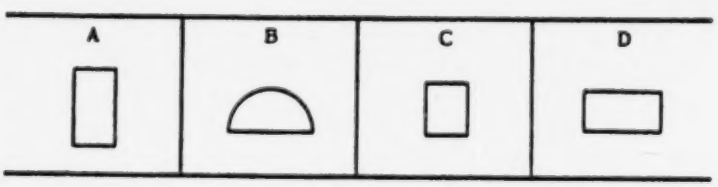
Example:

●	-	-	-	0	0	0
-	●	-	0	0	0	-
0	0	0	0	0	-	●
-	0	0	-	●	-	-
0	0	-	0	-	0	0
1	2	3	4	5	6	7

FIGURE EXCLUSION (11)

Figure Exclusion is used by Guilford as a measure of CFC and in the PMA 4-6 test battery as a measure of Reasoning (Induction). Permission was received from the publisher, Science Research Associates, Inc., to reproduce the test. It is called Figure Grouping in the PMA battery. From four given figures, the subject infers a class and then chooses the one figure which is different (does not belong to that class).

Example:



SEEING TRENDS (12)

This test is our adaptation of Guilford's Seeing Trends II test. The content of the test is word-form; words are used as collections of letters. Four exemplars are given. The subject infers a rule based on number of letters, alphabetic position of letters, etc., and places another exemplar in its proper serial position.

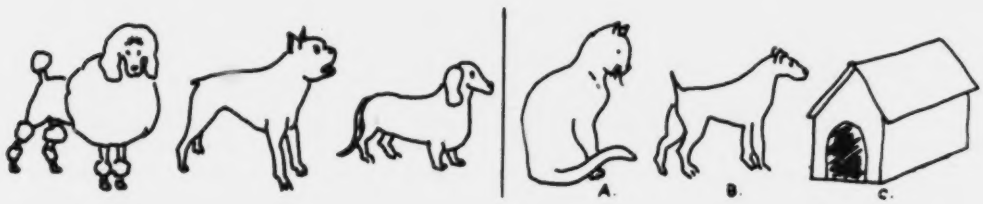
Example: six _____ five _____ fifty _____ one (nine)
A B C

PICTURE CLASSIFICATION (13)

This test was constructed to parallel the Verbal Classification test using picture-semantic content instead of verbal-semantic; the purpose was to study the relationships of getting meaning

from pictures and from words. Many of the items use the same exemplars as those used in the Picture Exclusion test to study the relationships between classification and exclusion type tasks without the confounding effects of specific content (exemplars). Pictures of three things which belong to a class are given. The subject is to infer the class and choose a fourth exemplar of that class.

Example:



PARAGRAPH COMPREHENSION (14)

This test consists of selected passages and questions taken from the Grade 5 Reading Comprehension test of the Iowa Tests of Basic Skills (1964). Permission was received from the publisher, Houghton Mifflin Co., to reproduce this test.

REMEMBERING CLASSES: NAMES (15)

This test is our adaptation of Guilford's Remembering Classes test. The subject infers a class name for 10 sets of four words each and is to remember these class names. He is tested by being asked to recognize the 10 class names from among 10 other class names.

Example: dog
cat
horse
rabbit

1. animals
2. plants

WORD GROUP NAMING (16)

This test is our adaptation of Guilford's Word-Group Naming test. Four exemplars of a class are given and the subject must supply a name for the class. This is a free response type test and requires hand scoring or coding. It should be pointed out here that the exemplars given for many of the items of this test are the same ones as those given for many of the items of three other tests-- Picture Group Naming (23), Picture Group Name Selection (47), and Class Name Selection (53). The purpose of this was to study the relationships among producing and selecting a class name when the exemplars are given in verbal-semantic and picture-semantic content; the exemplars were held constant so knowledge of specific things would be held to a minimum as a confounding influence.

Example: poodle
terrier are all _____
hound
collie

GPO 827-669-4

GESTALT COMPLETION (17)

This is our adaptation of the Thurstone-Street Gestalt Completion test, which has also been used by Guilford. Portions of our test were taken from the Gestalt Completion Test--C-1 in the ETS Kit of Reference Tests for Cognitive Factors (1962). The test involves naming an object from a partially obliterated picture of it. This test must be hand scored or coded as the subject produces the answer.

Example:

CARD ROTATIONS (18)

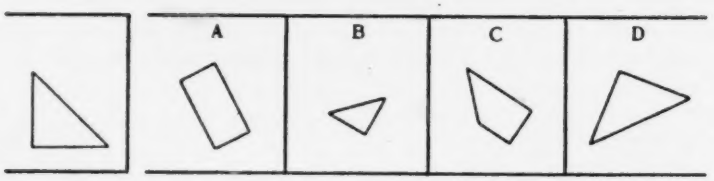
This is the Card Rotations Test--S-1, Part I in the ETS Kit of Reference Tests for Cognitive Factors (1962). It involves determining whether figures representing the same card as a given one but with a different orientation are merely rotated or are mirror images of the card (have been turned over). The subject responds directly on the test page and the test must be hand coded or scored.

Example:

SPATIAL RELATIONS (19)

This is the Spatial Relations test from the PMA 4-6 test battery. It was reproduced for use by the CAA Project with permission of the publisher, Science Research Associates, Inc. From four choices the subject chooses the figure that would complete a given figure to form a square.

Example:



VERBAL EXCLUSION (20)

This is our adaptation of Guilford's Word Classification test. From four given words, three of which are exemplars of a class and one nonexemplar, the subject infers a class and picks out

the nonexemplar.

Example: A. Sunday B. Thursday C. Yesterday D. Wednesday

BEST WORD CLASS (21)

This is our adaptation of Guilford's Best Word Class test. One word is given and the subject is to give the best class name.

Example: OAK is a kind of
A. plant
B. bird
C. food
D. tree

OMELET (22)

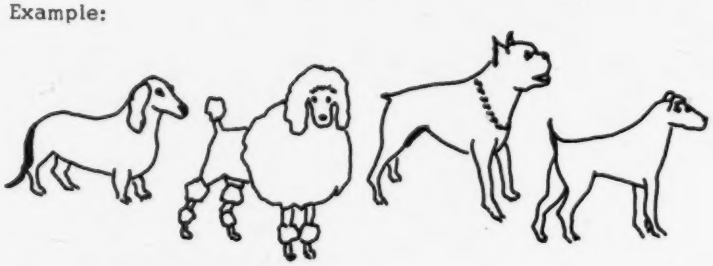
This is our adaptation of Guilford's Omelet test. It is an anagrams test. Familiar words are given with the letters in a scrambled order and the subject is to write the word spelled correctly. This test requires hand coding or scoring.

Example: orf _____

PICTURE GROUP NAMING (23)

This is our adaptation of Guilford's Picture-Group Naming test. Four exemplars of a class are given in the form of pictures. The subject is to infer the class and supply a name for it. This is a free response type test and requires hand scoring or coding. As was pointed out before, the exemplars given for many of the items are the same ones as those used for three other tests.

Example:



are all:

_____

CONCEALED WORDS (24)

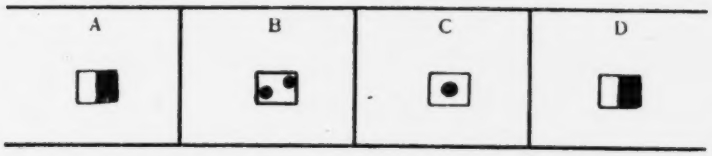
This is our adaptation of Thurstone's Mutilated Words test. Portions of our test were taken from the Concealed Words Test--Cs-2 in the ETS Kit of Reference Tests for Cognitive Factors (1962). The test involves the recognition and writing down of a partially obliterated word. The words used are all very familiar ones. This test requires hand scoring or coding.

Example: [illegible] _____

PERCEPTUAL SPEED (25)

This is the Perceptual Speed test from the PMA 4-6 test battery (1962). It was reproduced for use in this study with the permission of the publisher, Science Research Associates, Inc. The test involves the circling of the two identical figures from four given figures. It was administered under speeded conditions; three minutes were allowed to complete 40 items.

Example:



LETTER TRIANGLE (26)

This is our adaptation of Guilford's Letter Triangle test. Letters as members of the alphabet with ordinal position are presented in the form of a triangle with a blank appearing where one of the letters belongs. The subject is to find a spatial rule for the ordering of the letters and select, from three choices, the letter that belongs in the blank. Guilford used 15 letters and blanks in a five-row triangle in his test; we used five letters and one blank in a three-row triangle.

Example:

_
P L
F H J

1. O
2. N
3. M

LETTER CLASSIFICATION (27)

This test was constructed to measure the ability represented by the "classification of things with letter-symbolic content" cell in the Cognition of Concepts schema. It was patterned after the Letter Grouping (9) test which is an exclusion type task for things with letter-symbolic content. The subject is to infer a class from three given exemplars and add, from three choices, a fourth exemplar to that class.

Example:

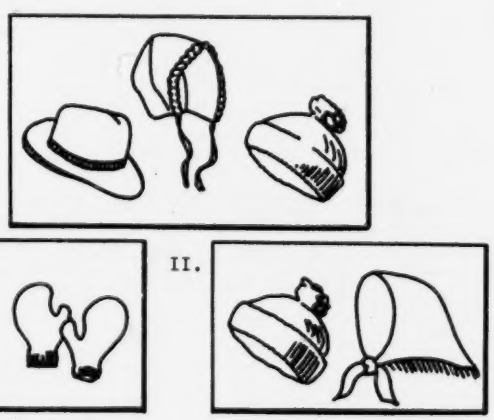
AAA
CCC
BBB

1. ABC
2. DDD
3. AAB

PICTURE CLASS MEMORY (28)

This is our adaptation of Guilford's Picture Class Memory test. The subject studies ten sets of three pictures each. The three pictures in each set are exemplars of a class. The subject infers the class, remembers it, and then judges whether or not 20 sets of two pictures each belong to a class that was studied. Each of the sets of two pictures to which the subject responds contains one picture from one of the sets which was studied. This was an attempt to make the test measure remembering of a class more than remembering specific exemplars of a class, which we felt might be more like remembering units (to use Guilford's terms).

Example:



PUZZLES (29)

This is a syllogistic reasoning test and consists of selected items from the "Test of Logical Ability" (Hill, 1960).

Example: If Ann is at school then she is the leader today.
Ann is not the leader today.

Is Ann at school?

SPELLING (30)

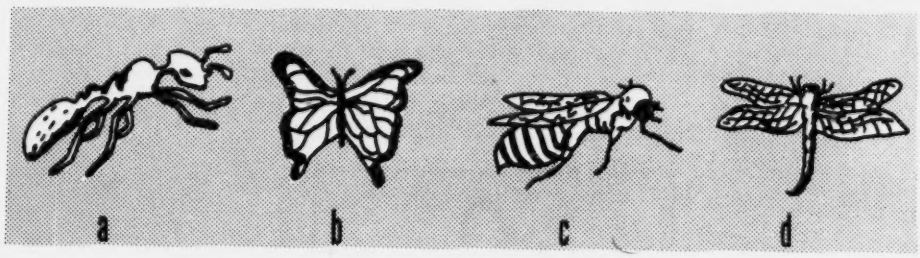
This test consists of 30 selected items taken from the Grade 5 Spelling test of the Iowa Tests of Basic Skills (1964). These items were reproduced for use in this study with the permission of the publisher, Houghton Mifflin Co. The entire Grade 5 test consists of 43 items; we did not use the first six and the last seven of these. The subject is to select the misspelled word if there is one, or to select "no mistakes" if each of four words is spelled correctly.

Example:
A. good
B. skool
C. book
D. jump
E. (no mistakes)

PICTURE EXCLUSION (31)

This test was constructed to parallel the Verbal Exclusion test using picture-semantic content instead of verbal-semantic content to study the relationships between getting meaning from pictures and getting meaning from words. As was discussed earlier, many of the items of this test use the same exemplars as those used in the Picture Classification test in order to study the relationships between the two tasks of classification and exclusion. Pictures of four things are given. Three of these belong to a class. The subject is to infer the class and choose the pictured object which does not belong to that class.

Example:



SENSITIVITY TO ORDER (32)

This is our adaptation of Guilford's Sensitivity to Order test. Four exemplars are given in their correct order with a fifth that is to be fit into this order in one of five places according to its proper serial position. Guilford gave five exemplars and asked that the order be rearranged if it was incorrect.

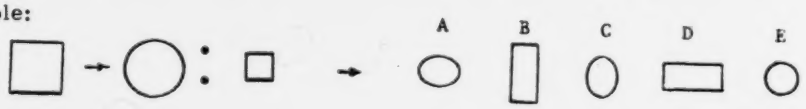
Example:

_____ Monday _____ Wednesday _____ Thursday _____ Friday _____ (Tuesday)
A B C D E

FIGURE ANALOGIES (33)

This is an analogies type test using figures rather than words. The test consists of 22 selected items from the 33 items of the Non-Verbal Test No. 3 of the Lorge-Thorndike Intelligence Tests (1964). These items were reproduced with the permission of the publisher, Houghton Mifflin Co. Items which contained pictures of things instead of figures and items which were of a series type, such as an increase in size of each succeeding figure, were not used.

Example:



SCRAMBLED SENTENCES (34)

This test consists of short simple sentences (4 to 11 words) that are presented in a scrambled order. The subject is to rearrange the words to form a sentence and then decide whether the statement of the rearranged sentence is true or false. To make it more of a school learning achievement type of test, the content of the sentences was taken from the four subject matter fields being studied by the CAA Project: language arts, mathematics, science, and social studies.

Example: above grow ground flowers

(When these words are correctly rearranged, do they make a true or a false statement?)

SAME-OPPOSITE (35)

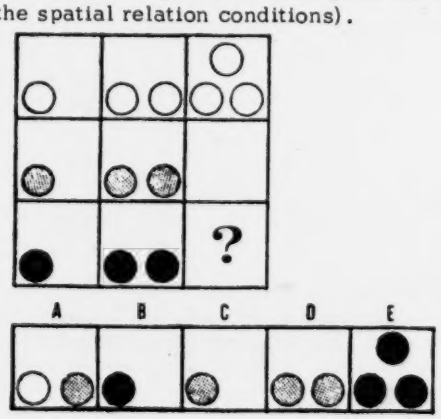
Two words are given for each item. The subject is to decide whether the two words are the same or about the same in meaning or are opposite or about opposite in meaning.

Example: big. . . large

FIGURE MATRIX (36)

This test consists of 20 selected items from Guilford's Figure Matrix test. Permission was received from Sheridan Psychological Services, Inc. to reproduce the test. We did not use Guilford's Items 11, 12, 19, and 24. Three or more cells of a three-row and three-column matrix contain figures. The subject is to infer two spatial relations (across and down), combine them, and select from five choices the figure that belongs in the cell in the bottom right hand corner (the figure that fits the spatial relation conditions).

Example:



REMOTE CLASS COMPLETION (37)

This test consists of selected items from the "WADDLE" test (Warren & Davis, 1970). They were used with the permission of the developers. Three words are given and the subject is to produce a fourth word that goes with all three of the given words. The words all belong together in some way, but the class is a remote one. This test requires hand coding or scoring.

Example: right fist shake _____

NUMBER EXCLUSION (38)

This test was constructed to parallel the Number Classification test but to require the task of exclusion instead of classification--it belongs in the "exclusion of things with number-symbolic content" cell in the Cognition of Concepts schema. Four exemplars, using numbers as symbols, are given. The subject is to infer a class and select the one exemplar that is incorrect for that class.

Example: A. 22 B. 55 C. 26 D. 33

SENTENCE ORDER (39)

This is our adaptation of Guilford's Sentence Order test. Three short and simple sentences which are in a random temporal order are given. The subject is to infer the proper order of events, arrange the three sentences in this order, and tell which sentence should come first and which sentence should come last.

Example: 1. Which sentence below should come first?

2. Which sentence below should come last?

A. I bought some apples.
B. Mother sent me to the store.
C. I ate an apple on the way home.

VOCABULARY (40)

This test consists of 30 selected items taken from the Grade 5 Vocabulary test of the Iowa Tests of Basic Skills (1964). These items were reproduced for use by the CAA Project with the permission of the publisher, Houghton Mifflin Co. The entire Grade 5 test consists of 43 items; we did not use the first six and the last seven of these. The subject is to select a synonym for the underlined word in a phrase.

Example: a <u>tall</u> building

A. high
B. wide
C. low
D. new

WORD RELATIONS (41)

This is our adaptation of Guilford's Word Relations test. It is a multiple-choice analogies test with two pairs of words presented to determine the relationship instead of only one. The subject is to infer the rule and complete a third pair by choosing the answer from five possible choices.

Example: top - pot
tip - pit
tap - ___

A. pet
B. tat
C. part
D. put
E. pat

VERBAL ANALOGIES (42)

This test consists of 24 items adapted from Analogy Questions (Gouber, 1967) with the permission of the publisher, Arco Publishing Company, Inc. Questions for 14 different types of relationships are included in the book; we used two items for each of 12 different types of relationships in the test. The types of relationships used were: action to object, association, antonym, cause and effect, characteristic, degree, object to action, part-part, part-whole, place, purpose, and sequence. We did not use grammatical and synonym types.

Example: HAND is to MAN as PAW is to

A. boy
B. dog
C. foot
D. bird

BEST TREND NAME (43)

Permission was received from Sheridan Psychological Services, Inc. to reproduce Guilford's Best Trend Name test. We made a few minor changes in the test to make it more appropriate for use with fifth graders. We replaced Items 10, 14, 16, 18, and 20 with new items and we used easier words for two trend names--importance instead of prestige and usefulness instead of utility. The subject is to infer a trend and select the name of that trend.

Example: horse - push cart - bicycle - car

A. speed
B. time
C. size

PICTURE ARRANGEMENT (44)

This test is Guilford's adaptation of Dorothy C. Adkins' test which was adapted from the comic strip "Louie." Sets of four pictures from a comic strip are given in a scrambled order. The subject is to infer the sequence of events and arrange the pictures in the proper order. This test requires hand scoring or coding.

Example:

ARITHMETIC PROBLEMS (45)

This test consists of working arithmetic problems of the following types: addition and sub-

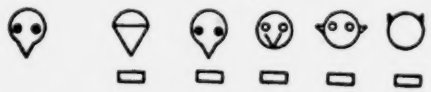
traction of fractions and decimals, division, and multiplication. The test requires hand scoring or coding.

Examples: $\frac{4}{5} - \frac{3}{5}$ $\quad 2.7 + 1.1$ $\quad 7\overline{)21}$ $\quad \begin{array}{r} 117 \\ \times\ 3 \end{array}$

IDENTICAL PICTURES (46)

This is the Identical Pictures Test--P-3, Part II from the ETS Kit of Reference Tests for Cognitive Factors (1962). It is a highly speeded test which involves selecting a figure from five possibilities which is identical to a given one. This test requires hand scoring or coding.

Example:



PICTURE GROUP NAME SELECTION (47)

This test was constructed to complete the picture versus word and naming versus name selection group of tests in order to study these relationships. As previously mentioned, the other three tests are Word Group Naming (16), Picture Group Naming (23), and Class Name Selection (53). Three pictured exemplars of a class are given. The subject is to infer the class and select the best name for the class.

Example:

are all:

A. animals
B. brown animals
C. dogs

NUMBER CLASSIFICATION (48)

This is our adaptation of Guilford's Number Classification test. Numbers are used as symbols. The subject is to infer a class, according to the form or structure of the numbers, from three exemplars and select another exemplar of that class. We used the same format as Guilford, short matching sets, with the modification of only three items and five choices in a set instead of four items and five choices.

Example:

I.	21	24	27
II.	79	89	19
III.	22	33	55

A. 39
B. 44
C. 12
D. 92
E. 23

WORD EXCLUSION (49)

This test was constructed to measure the ability implied by the "exclusion of things of word-

form content" cell in the Cognition of Concepts schema. From four words as collections of letters the subject is to infer a class rule and select the nonexemplar of the class.

Example: A. thought B. tot C. that D. twirl

NUMBER RELATIONS (50)

This is our adaptation of Guilford's Number Relations test. Four exemplars which are pairs of numbers are given. The subject is to infer a quantitative rule for the relationship of the number pairs and select the exemplar which does not follow this rule.

Example:
A. 3, 4
B. 1, 2
C. 4, 6
D. 2, 3

WORD LINKAGE (51)

This is our adaptation of Guilford's Word Linkage test. Word pairs, with both words having a common double meaning are given. The subject is to select the common double meaning, i.e., a word that is related to both of the given words.

Example: airplane--insect
A. fly
B. passenger
C. bug

FIGURE CLASSIFICATION (52)

This is a classification type test using figures. The test consists of 20 selected items from the Non-Verbal Test No. 1 of the Lorge-Thorndike Intelligence Tests (1964). These items were reproduced with the permission of the publisher, Houghton Mifflin Co. All 16 of the items from Levels B and C that were not serial in type, e.g., the exenplars increase in size, were used. To obtain 20 items we used the last two items from the preceding level and the first two items from the succeeding level. Three exemplars are given and the subject is to infer a class and select another exemplar of that class.

Example:

CLASS NAME SELECTION (53)

This is our adaptation of Guilford's Class Name Selection test. As discussed earlier, it is one of the four included in a group to study the relationships between getting meaning from words versus getting meaning from pictures and providing a class name versus selecting a class name. Four exemplars of a class are given and the subject is to irfer the class and select the best class name.

Example: poodle, terrier, hound, collie — are all
A. animals
B. dogs
C. brown animals

NECESSARY ARITHMETIC OPERATIONS (54)

This arithmetic reasoning type of test was originally used by Thurstone. It is the Arithmetic Reasoning test from the NLSMA Reports (1968) which was suggested by the Necessary Arithmetic Operations Test--R-4 from the ETS Kit of Reference Tests for Cognitive Factors (1962). A problem is given but the subject does not have to solve it; he is asked only to select the operations required for solving the problem.

Example: Jane's father was 26 years old when she was born. Jane is now 8 years old. How old is her father now?

A. subtract
B. divide
C. add
D. multiply

VERBAL ANALOGIES III (55)

This is Guilford's Verbal Analogies III test. Permission was received from Sheridan Psychological Services, Inc. to reproduce it. We changed nine of the distractors, one for each of nine items, to make the test more appropriate. Guilford says it is different from a typical verbal analogies test in that the alternative answers are close together in competition for completion of the analogy, thus making perceiving the right relationship the important feature in correctly answering the item.

Example: TRAFFIC : SIGNAL as RIVER : _____

A. bank
B. dam
C. canal
D. sand bags

REMEMBERING CLASSES: MEMBERS III (56)

This test is identical to Test 4, Remembering Classes: Members. It was administered as the last test in the battery without restudy of the material given. Thus, it is a third administration of Test 4 with three days intervening for boys and seven days for girls.

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Appendix A
Alphabetical Listing of Tests

Arithmetic Problems (45)
Best Trend Name (43)
Best Word Class (21)
Card Rotations (18)
Circle Reasoning (10)
Class Name Selection (53)
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Disemvowelled Words (8)
Figure Analogies (33)
Figure Classification (52)
Figure Exclusion (11)
Figure Matrix (36)
Gestalt Completion (17)
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Letter Grouping (9)
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Number Class Extension (5)
Number Classification (48)
Number Exclusion (38)
Number Relations (50)
Number Series (3)
Omelet (22)
Paragraph Comprehension (14)
Perceptual Speed (25)
Picture Arrangement (44)
Picture Class Memory (28)
Picture Classification (13)
Picture Exclusion (31)
Picture Group Name Selection (47)
Picture Group Naming (23)
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Remembering Classes: Members II (7)
Remembering Classes: Members III (56)
Remembering Classes: Names (15)
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Scrambled Sentences (34)
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Sensitivity to Order (32)
Sentence Order (39)
Spatial Relations (19)
Spelling (30)
Verbal Analogies (42)
Verbal Analogies III (55)
Verbal Classification (2)
Verbal Exclusion (20)
Vocabulary (40)
Word Exclusion (49)
Word Group Naming (16)
Word Groups (6)
Word Linkage (51)
Word Relations (41)

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Institute for the Study of Intellectual Behavior
Universiy of Colorado

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